U.S. GRAIN MARKETING RESEARCH LABORATORY

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PREFACE

This summary report reviews activities and accomplishments of the U.S. Grain Marketing Research Laboratory (USGMRL) in FY 1980. Like the previous reports, it concentrates on what happened during the past year. It has been a year of continued redirecting of some of our resources that strengthened our programs in line with our objectives to maintain a viable and balanced program. It goes without saying, redirection is easier said than done. The redirection has made possible good use of our two strongest assets: (1) the availability, under one roof, of human and physical resources for interdisciplinary research, and (2) the recognition that long-range basic and applied research, responsive to immediate needs, are companions for successful and valuable research.

This year has been one of large-scale testing to demonstrate the usefulness of microbial insecticides, to evaluate the use of mechanical devices and application of additives to reduce hazard of dust explosion, to follow changes in specific grain components as indices of incipient deterioration during storage, and to evaluate the usefulness of a commercial device to measure sprout damage in cereal grains. We have found that the time-proven route from new concepts through applied investigations in the laboratory, pilot plant, and field to development of new products or methods and extension of that information to the user and consumer is still the best return on the taxpayers' investment in research.

Some of our studies were conducted in cooperation with scientists in other U.S. Department of Agriculture (USDA) research facilities and in several universities. Most of our collaborative studies were with researchers at the Kansas Agricultural Experiment Station and represented effective and mutually beneficial cooperative efforts. We conducted several collaborative studies within technical committees of the American Association of Cereal Chemists, the International Association of Cereal Chemists, and the Regional Project NC-151 (that has a nationwide and international scope) on marketing and delivery of quality cereals and oilseeds in domestic and foreign markets. An increasing number of projects involved cooperation with several action-regulatory agencies in USDA: The Federal Grain Inspection Service (FGIS), Agricultural Marketing Service, Animal and Plant Health Inspection Service, Foreign Agricultural Service (FAS), the Agricultural Stabilization and Conservation Service, and the Economics and Statistics Service (ESS).

While getting to the top may be more exciting, staying at the top is certainly equally challenging and important. The past year has been a difficult one to maintain a center of scientific creativity and sustained research productivity in a changing environment that posed increasing numbers of urgent demands for new information, research findings, and solutions. It has been a good year. The facts and accomplishments speak for themselves. They are given in the list of publications and oral presentations and are highlighted in this preface.

We have completed a light and electron microscopic study on the subaleurone endosperm of maturing hard red winter wheat, have followed changes in protein bodies, and have related the findings to physiological maturity and loaf volume potential. We have investigated the use of the colorimetric alpha-amylase test in evaluating commercial malts, malt supplementation, and sprout damage in various cereal grains. We have conducted a series of studies on susceptibility to breakage of corn and soybeans in marketing channels, have standardized a device for measuring such susceptibility, and have demonstrated the usefulness of the standardized instrument. Four methods to determine grain hardness (power requirements and time to grind whole wheat and particle size and near-infrared reflectance of ground wheat) were studied, compared, and evaluated in objectively measuring composition of mixtures, hardness of cultivars, and differences between dark, hard, and vitreous, and yellow-hard kernels. Activity of glutamic acid and decarboxylase has been correlated with percent germination in wheat, and the possibility of making a similar correlation for barley was investigated.

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A malathion-resistant strain of the Indian meal moth was found to have twelve fold higher levels of a malathion-degrading carboxylesterase enzyme than the standard (susceptible) lab strain. Both the resistance and the high levels of esterase were shown to be controlled by a single genetic factor, which was completely dominant. We found several insect growth regulators that prevent metamorphosis that were effective population suppressants for beetles and moths in stored grain. The physical and chemical properties of several molting enzymes from cultured insect cell lines also were determined.

In FY-1980, we initiated a 3-year pilot test to develop practical methods for applying *Bacillus thuringiensis* to farm stored grain and to demonstrate the effectiveness of the treatment to farmers and state extension specialists. Formulations of *B. thuringiensis* were approved in 1979 for use on stored grain for controlling moth infestations as a result of research conducted at the USGMRL. During the last year, we have been able to expand our work on stored grain insecticides with the addition of two insect toxicologists to our staff. Studies have been initiated on the metabolism of insecticides by stored grains and on the physiology of insect resistance to insecticides.

Minimizing fuel requirements for grain drying, namely, using solar energy, and evaluating test results conducted during the last six fall seasons have enabled us to recommend a solar heat, in-bin, grain-drying system.

We have continued our search on handling, control, and utilization of grain dust. Characteristics and utilization methods of grain dust, reduction of dust generation by additives and mechanical devices, causes and prevention of grain dust explosions, and reduction of grain damage from handling were studied intensively. We determined particle size, mineral composition, and amino acid composition in dusts from various grains from various locations in the grain elevator. The significance of wheat flour lipids was demonstrated in reducing dustiness. Other engineering work involved a four-point self-leveling spreader to fill grain bins to produce uniform distribution of grain. We conducted experiments on distribution of fine materials and broken kernels and pressure drop through the grain beds and developed a mathematical model to predict the results.

We have continued to evaluate functional (milling and baking) properties of potentially new hard winter wheats. We are proud to be part and one of the focal points of a regional breeding program for the major wheat crop that resulted in producing higher yielding cultivars with increased protein contents. We have found that satisfactory low-lactose, white-panned bread can be made from a dough that contains lactase-treated milk. The deleterious effects (in breadmaking) of high fiber (wheat, corn, or soybean bran) can be counteracted largely by the addition of vital gluten and one of several surfactants. We have completed a study on the distribution of alpha-amylase in mill fractions of sprouted soft white winter wheat and have determined the effects of sprouting on Japanese-type sponge cake and related physical and chemical tests. The usefulness of the gasograph was demonstrated to measure and record, continuously, the gas produced in fermenting doughs.

We have studied the effects of high levels of shortening in breadmaking and the extent to which they can replace native flour lipids. Corn proteins, similar to purothionins, were purified and characterized, and the sequence of purothionins and their inheritance in diploid, tetraploid, and hexaploid wheats was determined and compared.

Polyacrylamide gel electrophoresis (PAGE) of wheat gliadin proteins is potentially a useful tool for identifying wheat varieties. We have developed a standardized PAGE method and used it to catalog 80 of the major U.S. wheat varieties (hard red winter, hard red spring, soft red, common white, white club, and durum) that were grown on 0.2 percent or more of the total U.S. wheat acreage. The use of PAGE in determining gliadin composition of triticales and their wheat and rye parents was demonstrated.

Our scientists have organized and participated in several symposia. They included a symposium on the theory and application of lipid-related materials in breadmaking (October 1979, American Association of Cereal Chemists, Washington, D.C.); on starch composition and functional properties (May 1980, International Association of Cereal Chemists, Vienna, Austria); on microbial insecticides (August 1980, 16th International Congress of Entomology, Kyoto, Japan); and on nondestructive testing (September 1980, American Association of Cereal Chemists, Chicago, Ill.).

During the past few years, we have experienced a significant growth in our knowledge and understanding of many aspects of the grain dust explosions. The continuing concern over the hazard and nuisance of grain dust resulted in our broad studies on grain dust. After the successful international symposium on grain dust October 2-4, 1979, we organized a symposium on "Dust Explosions" in September, 1980, at the Fine Particle Society Meeting in Washington, D.C. The symposium was to examine the progress that had been attained from previous and continuous studies on grain dust explosibilities, and subsequently to interrelate and interpret these results and conclusions to obtain a broader understanding of present knowledge and research needs.

We have gathered and made available to the scientific and technological community, and to the grain trade and industry in Grain Dust Abstracts, USDA, Bibliographies and Literature of Agriculture No. 12, a single, comprehensive, and authoritative source of information of all the published literature. The abstracts will be published annually. In the first issue, we covered literature sources published up to 1979 that were not covered in the Review of Literature Related to Engineering Aspects of Grain Dust Explosions, USDA, Miscellaneous Publication No. 1375. Subsequent publications will be on an annual basis. The subjects cover handling, control, and use of grain dust. An annotated bibliography on chemical preservation of high-moisture grain is in press.

The value of our research depends on its acceptance by the target recipients. That acceptance involves an economic assessment of cost and impact. We are pleased to have the fine cooperation of the scientists from USDA's Economics and Statistics Service at USGMRL. Their continued evaluation of the economic feasibility of several of our programs adds an important dimension to our work.

The excellence of our scientists continues to be recognized by prestigious scientific awards from professional organizations, numerous invitations to present lectures, appointments to editorial boards, selections to organize national and international symposia and short courses, and appointments to act as scientific editors of prestigious series of advances. We are gratified by the great number of visitors to our laboratories. Distinguished visitors of varied scientific professions from 54 countries and from 30 states of the United States came to see our research facilities, to acquaint themselves with our activities, to share their thinking with us, and to consult with our scientists about novel approaches and new developments. Their stays ranged from a short visit to a year of research work. Those visits, along with innumerable requests for information, interviews, lectures, and participation on committees, acknowledge our diversified activities as a center of Grain Marketing Research.

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GRAIN STRUCTURE, COMPOSITION, AND CHARACTERIZATION UNIT

Scientists in this unit conduct investigations to (1) identify composition of cereal grains in relation to storage, handling, utilization, and nutritional value; (2) determine relation of structure of cereal grains to storage, handling, and utilization; (3) determine use of enzymes in determining composition, structure, storability, and damage during handling of cereal grains; (4) identify, control, and eliminate mycotoxins from cereal grains; and (5) assay the protein content and biological value of cereal grains, in particular, maize and sorghum.

Grain Composition

In these studies, our approach is to determine protein, lipid, mineral, and carbohydrate contents and interaction products among grain components as they relate to storage, handling, utilization, and nutritional value. The studies are designed to provide information, on composition of cereal grains, to other units in the USGMRL in investigating the effects of composition on handling, storage, end-uses, nutritional value, and development of quality tests. Examples of studies in this area include determination and characterization of lipids (including the role of lipids in breadmaking), interaction between lipids and proteins, and determination and characterization of proteins. The information has been used to develop nutritionally improved, consumer-acceptable baked products.

Grain Structure

We study cereal grains and products of their processing by microscopic methods—light and scanning and transmission electron microscopy. These studies are designed to correlate grain structure with market quality investigations conducted in other research units in the Laboratory. Examples of studies in this area include comprehensive investigations on the structure of cereal grains, changes in the structure of dough and bread, structure of dough and bread from flours varying in breadmaking quality, and relation of grain structure to handling (corn breakage), storage (damage by molds and insects), end-uses, nutritional value, and development of quality tests.

Use of Enzymes

Enzymes are used to determine composition (proteins, carbohydrates, lipids, glycolipids, lipoproteins, and glycoproteins) and nutritional value of cereal grains, including availability of nutrients and their modification during handling, storage, and processing. Enzyme activity is assayed to determine grain quality (at sprouting and deterioration during handling and storage). We design the studies to provide information on composition, as determined by enzymatic assays, and on levels of enzymes in cereal grains to other units at the Laboratory for determining soundness, characterization, and development of quality tests. Enzymes will be used to determine, selectively and specifically, trace amounts of nutrients or contaminants in mold, insect, or rodent infested grain. Examples of studies in this area include determining sprout damage and differences in alpha-amylase in sprouted wheats and malts from various classes and locations and developing a mobile unit for field determination of alpha-amylase.

Mycotoxins

In mycotoxin research, we develop analytical procedures, preferably suitable for use in grain-marketing channels, for detecting specific fungal components as measures of extent of invasion, mycotoxins, and other fungal metabolites; and for identifying fungi-grain interrelationships that may regulate invasion of particular grain types, varieties, or hybrids by specific genera or species of fungi. The approach used in these studies is to apply optimized extraction and chromatographic techniques and to simplify and make more effective initial extraction, clean-up, and final detection steps. Metabolites are evaluated as measures of fungal invasion on grains and are compared with mycological and other tests such as discoloration, germination, fat acidity, and odors. Differences in susceptibility to invasion by fungi among grain types, varieties, or hybrids, especially sorghum, also are investigated.

Corn and Sorghum Quality

We conduct these studies to assay the protein contents and chemical score, based on amino acid content, of corn and sorghum. In addition, laboratory scientists compare various methods for routine determination of protein contents and quality in samples from plant breeders and from commercial channels.

BIOLOGICAL RESEARCH UNIT

The Biological Research Unit is concerned with fundamental and applied biology of insects and microorganisms that infest stored grains and cereal products. Insects and microorganisms are the principal kinds of organisms that adversely affect grain quality. Insect and microbial activity in stored grains decrease germinability, discolor part or all of the seeds or kernels, cause weight loss, reduce nutritional value, produce heat, and increase moisture. The latter two factors, in turn, bring about physical, chemical, and physiological changes in the grain. Some insects feed on whole grain, others on broken kernels, thereby increasing the percentage of broken kernels and dockage. Some microorganisms produce toxins that are injurious to man and to domestic animals. Grain and cereal products are subject to insect and microbial infestation, damage, and contamination while in the marketing channels. The Federal Government, the food storage, transportation, and processing industries, and the consumer suffer large monetary losses from grain insects causing damage and downgrading and making the products unfit for human consumption. The presence of insects and the damage done by them affects us adversely in the highly competitive foreign market.

Another cause for concern in relation to foreign trade in grain is that pesticide and fumigant residues are receiving increasingly critical scrutiny in the European Common Market countries as well as in other parts of the world. These residues also are of concern for the domestic market. Urgently needed are more acceptable and effective methods for preventing insect damage and contamination during storage, handling, processing, packaging, transportation, and retail distribution. The need is critical for effective pesticides and application methods that can be used in our domestic and foreign markets without leaving objectionable residues. Even more desirable is the development of effective preventive and control measures using biological, physical, mechanical, or other nonchemical means that would reduce or completely eliminate the use of pesticidal chemicals.

The primary mission of the Biological Research Unit is to gain adequate knowledge of insects and microorganisms and their storage environment to develop appropriate techniques and methods of pest management under experimental and practical conditions. Research is divided into the following areas.

Insect Biochemistry and Physiology

Our research in this area is to study the growth and development of stored grain insects to determine unique biochemical and physiological processes that are potential targets for new insect control agents. This approach to insect control uses a class of insecticides called biorational because of their specificity to insects and because they exhibit little or no adverse effects on man, wildlife, domestic animals, and the ecosystem. The program includes basic research in insect biochemistry, endocrinology, and morphology, and applied research in developing biorational compounds that specifically inhibit particular aspects of an insect's physiological and behavioral processes. Compounds receiving special attention are insect growth regulators with hormonal activity such as juvenile and molting hormones, glucagon, and insulin, and those that interfere with exoskeleton production, energy metabolism, reproduction, and sensory perception. The susceptibility of strains of the confused flour beetle, red flour beetle, lesser grain borer, rice weevil, granary weevil, maize weevil, sawtoothed grain beetle, cigarette beetle, Indian meal moth, and navel orangeworm to these chemical agents is being investigated.

Chemical Pesticides

Research is directed toward establishing the effectiveness and stability of insecticides as grain protectants, bin treatments, and vapor toxicants. We are developing effective and efficient procedures for integrating suitable materials into grain management systems. Studies include the influence of biological, chemical, and physical factors on insecticide effectiveness, spectrum of activity, and residue retention or metabolism on various grains, and the nature, causes, and incidence of insect resistance to insecticides. These studies specifically address the problems posed by decreased insecticide stability under high moisture and temperature conditions and by the increasing incidence of insect resistance to insecticides. Studies also are focused on specific infestation problems caused by changing grain harvest and storage procedures, such as sanitation in and around grain drying equipment, insect control in larger storage facilities, and longer term storage. We recognize that a single set of infestation control recommendations will have limited usefulness because of the diversity of commodities and storage practices. Therefore, commodity characteristics and management practices are critical elements of each study in this area.

Insect Pathology

Investigations include developing methods for using microbial insect pathogens to prevent and control insect infestations in stored grain and processed products. Basic and applied research entail studies of the structure, physiology, and mode of action of selected bacterial and viral insect pathogens; susceptibility of strains of the Indian meal moth and almond moth to *B. thuringiensis* and granulosis virus, differential toxicity of *B. thuringiensis* isolates, and efficacy of commercial formulations of *B. thuringiensis;* structure, toxicity, and biosynthesis of the entomocidal protein of *B. thuringiensis;* and effects of commodity characteristics, storage environment, biology and behavior of the target insect species, development of resistance to pathogens, and interactions with unaffected insect species on the use of insect pathogens for stored grain insect control.

Pest Bionomics

Research in this area is conducted to determine the influence of inert atmospheres—produced by exothermic inert atmosphere generators—on toxicity, fecundity, fertility, and development of the major stored grain insects. In other studies, we examine the influence of temperature and moisture on the response of insects to the atmospheres produced by an exothermic inert atmosphere generator; the effects of applying modified atmospheres to bulk stored commodity ecosystems including insect populations, functional and biochemical properties of the treated commodity, and fungistatic activity; and the current costs of conventional chemical treatment of grain compared to the costs of installing and operating exothermic inert atmosphere generators to control insects in bulk stored grain, in cooperation with the ESS.

This program also includes a study to identify biological problems, both insect and microbial, associated with environments that occur in transported grain and that contribute to physical losses, reduced quality, and increased transportation costs.

Genetic Resistance in Seeds

Basic and applied biology are under investigation with grains that exhibit preference, antibiosis, and tolerance to insects and microorganisms. Specific attention is given to naked and hulled barleys and to several wheat varieties that exhibit differences in their response to certain insects and fungi. For those grains found to be resistant, efforts are made to determine the site in the grain and the cause of resistance. Planned work will involve genetics of resistance, hybridization techniques to combine resistant genes in seeds with desirable agronomic characters, resistance tests in advanced generation hybrids, and evaluation of resistant grains in laboratory and field trials. Specific lines of work will include isolating, purifying, identifying, and evaluating chemical constituents of grains that repel or attract insects and microorganisms and determining genetically controlled structural and morphological characteristics of resistant grain varieties.

ENGINEERING RESEARCH UNIT

Researchers in the Engineering Research Unit conduct investigations to (1) develop and evaluate chemical, biochemical, physical, and physiochemical methods, and develop instruments for characterizing and determining the quality of cereal grain; (2) minimize fuel energy required for grain drying; (3) measure and control dust from grain handling; and (4) reduce damage to grain from handling. Recent progress in these areas of research is summarized as follows.

Barley Germinability

Activity of the enzyme glutamic acid decarboxylase has been correlated with percent germination for wheat, corn, rice, and oats. Because a rapid method is needed to measure percent germination in barley to be used for malting, we examined the relationship between activity and germinability of barley. A simple, rapid procedure was developed for measuring activity of the enzyme by determining the rate of carbon dioxide evolution from a buffered glutamic acid solution in which a ground barley sample was suspended. We measured carbon dioxide by nondispersive infrared analysis and determined such optimal conditions as pH and substrate concentration.

Our studies indicate that, for barley, a significant correlation exists between glutamic acid decarboxylase activity and percent germination. The correlation was better for six-row barley samples than for combined six-row and two-row samples. Although only a limited number of samples were examined, the correlation was highly significant, and a similar correlation would be expected for other cultivars. The data do not answer the question of whether one might occasionally encounter high-germination samples with low glutamate decarboxylase activity or low-germination samples with high activity.

Wheat Hardness

We conducted extensive studies on wheat hardness. The Brabender hardness tester was modified to measure the work in joules to grind 25 g to 55 g of wheat and to provide a digital readout of the data. Temperature (18° to 20° C), protein content (10.5 to 15.9 percent), kernel size, and growth location had little effect on the results, but the work required to grind wheat increased with increasing moisture content (7 to 13 percent). The average work was 530 joules (standard deviation 5.3) for 60 samples of a very hard red winter (HRW) wheat. The assay may be suitable for distinguishing between hard and soft wheats.

A Brabender automatic micro hardness tester was used to measure the time required to grind 4 g of wheat. Effects of temperature and moisture were determined. Increasing temperature from 15° to 40° C generally decreased grinding time, but differentiation among samples was better at 15° C than at higher temperatures. Increasing moisture content increased the grinding time of soft wheat much more than it increased the grinding time of hard wheat. The tester can detect differences, related to processing and end-use properties, and in hardness among some wheat classes and among some varieties representing a single class of wheat. The instrument can also be used to evaluate hardness of plant-breeders' samples, so that selections with extreme hardness or softness can be discarded, and to distinguish between hard and soft wheats in marketing channels.

Four methods (work to grind, time to grind, particle size, and near infrared reflectance of ground wheat) were used to measure the hardness of cultivars representing durum, hard red spring, HRW, white, white club, soft white winter, and soft red winter wheats. We noted no consistent effect of wheat protein content on hardness values measured by any of the four methods. Durum wheat can be distinguished from other classes by three of the four methods. HRW wheat can be distinguished from hard red spring wheat by three of the four methods. White and soft red winter wheats can be distinguished best from each other and from the remaining classes by the Brabender automatic micro hardness tester that measures time to grind a 4-g wheat sample. The near infrared hardness value measured at 1,680 μm will distinguish between hard and soft wheats and between durum and all other wheat classes.

Dark, hard, and vitreous (DHV) and yellow hard (YH) fractions from three HRW wheat cultivars (each from three locations) and five commercial HRW wheat samples ranging in DHV from 27 to 63 percent were analyzed by measuring the time or the power required to grind whole wheat and by particle size and near infrared reflectance (NIR) of ground wheat. DHV kernels were harder than YH kernels, but there was no consistent difference in milling quality of the commercial samples. The percentage of DHV kernel content and the hardness of commercial samples were highly significantly related as measured by time or power required to grind wheat and the NIR of ground wheat.

We studied the effects on corn breakage susceptibility of several modifications of a Model CK2 Stein breakage tester. Modifications consisting of an improved impeller assembly, thicker, longer, and harder blades, and a stainless steel cup, have been incorporated in the Model CK2-M Stein breakage tester currently in production. Use of the modified instrument doubled the breakage of breakage-prone corn and lessened the time required to determine the percentage of breakage.

Minimizing Fuel Energy Required for Grain Drying

Methods for using solar energy for bin drying of grain are being developed. During the last six fall harvest seasons, researchers in the Engineering Research Unit conducted farm-scale drying tests of freshly harvested, high-moisture corn and sorghum with two systems: experimental, air-type, solar collectors and natural air. The solar collector, air-heating units used with natural air-in-bin grain drying systems were effective in utilizing solar energy by increasing the drying potential of ambient air. The solar units reduced the electrical energy required to accomplish drying when compared to that required for concurrent natural air bin drying.

An axial, flow-drying fan dissipated most of the electrical energy as heat to the air supplied to the grain bin. Airflow volumes to accomplish velocities of 0.10 to 0.15 m/s (20-30 ft/min/ft^2) of drying floor area increased management options, drying potential, and opportunity for a batch, multiple-drying procedure.

A batch in-bin drying technique employing a combination of reduced grain depth and higher airflow-rates allowed earlier harvesting of grain at a higher moisture content without risking grain deterioration. Batch drying, followed by transfer mixing of the driest and wettest grain, increased utilization of the drying equipment and permitted more grain to be dried per season. Energy for drying came from solar and atmospheric heat, plus electricity for fan operation. During periods of favorable weather, less electricity was used per unit of moisture removed in drying bins using solar heat than in comparable bins employing natural air. Solar-heated air was more effective than ambient air when the drying periods included rainy or cold weath-

er. Mold development was most apparent during warm, humid weather in grain with more than 22 percent moisture and was not affected by applying solar heat.

In another project in cooperation with the ESS, we studied the detailed economics of batch in-bin, and layer in-bin, solar, and natural grain drying. The grain-drying results with the various drying strategies were simulated with a computer program developed by USDA's Science and Education Administration-Agricultural Research (SEA/AR) in cooperation with Iowa State University at Ames, Iowa. Twenty years of grain drying were simulated, using weather data from Dodge City, Kans. This study indicated that neither solar heat nor any other form of supplemental heat can be used economically in the west central Great Plains as long as the size of corn discounts and the price of corn itself are low in relation to the cost of items—labor, fuel, and materials—related to artificial drying. Such economic relationships encourage the marketing of poor quality products.

Efficient Solar Grain Drying Systems

Planning acceptable, energy-efficient, grain-drying techniques require evaluation of harvesting, handling, drying, and storage facilities available to the farm operator. Planning requires assumptions defining the grain for harvest and expected moisture content. Weather conditions, time of year, and volume of grain to be harvested are variables for evaluation.

Harvest Planning and Efficient Procedures—Energy economics are greatest with fall harvested grains because of seasonal, cool, wet weather conditions. Energy-efficient grain handling, drying, and storage methods need to be versatile enough to receive both corn and sorghum within a workable time schedule. Our studies of grain drying with natural air and solar heat, in-bin systems have covered a 6-year period and a range of Kansas climatic conditions. Factors considered included grain depth, initial moisture content, ambient air temperature and dew point, solar radiation data, time of fan operation, and electrical energy supplied by fan motors.

Harvest Management—Wet grain for the cash grain market represents a harvesting-drying-storage process of major importance. On-the-farm drying offers an energy saving because less water is transported to market.

Corn plant maturity assessment, field inspections, and selection of the initial field for combining are important energy-efficient factors for the season. Corn plants mature, leaves and stalks turn brown, and the percentage of ears turned down differ with plant hybrid characteristics and weather conditions. Ears remaining upright on dry stalks absorb more rainwater and maintain a wide range in grain moisture content with the exposed ear tip kernels becoming 5 percent dryer than the kernels on the shank portion of the ear. A field with dead stalks should be scheduled for harvest as soon as field and work conditions will allow.

Sorghum plants are different than corn stalks since they do not die until a killing frost. Sorghum heads become dry enough for combining, storing, or marketing the grain while the stalks are still green. Warm sunny days, 30° to 35° C, and afternoon, low-humidity air conditions are ideal for early sorghum harvest.

In-Bin Grain Drying Equipment and Capacity—An evaluation of in-bin drying of corn and sorghum from experiemental test periods conducted during the last six fall seasons provided valuable performance, drying rate, and energy input data. Most of the tests were run in bins with full perforated floors of 15-ft and 18-ft diameters. Airflow rates ranged from 2.0 to 7.5 cfm/bu. Some test periods were run during warm weather while some periods were run during cold winter weather. Past results have given us a basis for estimating the drying potential of larger bins and different size drying fans. Vane axial fans have demonstrated excellent energy conversion of the electric power input to heat, resulting in a temperature rise for air supplied to the grain. In-bin, high-airflow drying requires additional roof openings or exhaust air ventilator openings.

The Two-Stage Grain Drying Strategy—First stage solar heat and natural air-drying systems use batch-in-bin techniques with relatively shallow drying bed depths—5 to 9 ft—depending on the average harvest, grain moisture content. Adequate size, vane-axial fans were used to accomplish 5 percentage points of moisture reduction with two, clear weather, sunny days and nights of operation. Adequate in-bin sweep auger and unloading equipment provided transfer rates to meet the harvest rate time schedule—800 to 1,000 bu/h. Electric power service was adequate to supply 5 to 6 kWh/bu for batch drying.

Full use of the drying bin, perforated floor area required airflow volumes of 25 to 30 fpm velocity through the floor. By using a grain bin spreader, we reduced the labor required for leveling wet grain. Percentages of fine material, machine damaged kernels, and foreign material must be evaluated for each bin lot of grain.

Second Stage—Grain Aeration and Storage Units—Final drying and cooling to maintain grain quality can be accomplished economically by low-power aeration systems and suitable storage facilities. The functions of aeration are to equalize grain moisture content

and to maintain a uniform cool temperature to retard mold growth.

Pressure aeration, pushing the ambient air through the grain, conserves fan energy, improves airflow distribution, and moves heat out of new grain that has been added to a partially filled storage bin. Fans pushing air upward through newly harvested or dried grain result in a reduction of 1/3 to 1 percentage points of additional moisture.

Mechanism of a Grain Dust Explosion as Affected by Particle Size and Composition

Grain dust explosions have become a topic of much concern in the last few years. A dust explosion is a rapid combustion reaction of a solid reactant, for example, grain dust. The composition and the particle size of the dust particles are important parameters. Therefore, much has been postulated about the effect of particle size and composition, and some studies have been performed with several types of dust. Little has been done, however, to study the explosibility of different size particles and the composition of a specific type of grain dust.

Each of three types of grain dust—namely, grain sorghum, corn, and wheat dust—and cornstarch was divided into 6 to 11 size fractions utilizing air and sieves. We determined the particle size distribution and the composition, in terms of moisture, ash, protein, starch, and fiber contents for each size fraction. Large amounts of particles with diameters smaller than the sieve apparatuses were retained on the sieve, unless the sieving was carried out carefully. Particles consisting almost entirely of ash concentrated in particular air classified size fractions.

The average diameter based on external surface area, the average diameter based on mass, and the coefficient of variability were calculated from each experimental particle size distribution, utilizing a piecewise, log normal approximation. We compared those values to values calculated from a least squares fitted log normal approximation of the actual distribution.

The minimum explosible concentration, C_{min}, of the dust in each size fraction was determined using the Hartmann apparatus. The minimum explosible concentration was correlated to the mass mean diameter, D_m, and to the concentration each of the composition components. Correlations between C_{min} and D_m for corn dust and grain sorghum dust, and between C_{min} and moisture content for corn dust, grain sorghum dust, and cornstarch, were significant. According to models developed in this work, a linear correlation should exist between $1/C_{min}$ and the specific external surface area, S_{ext}, and between $1/C_{min}$ and each composition component. In addition, the models were fitted to the experimental data. The coefficients of determination ranged from 0.80 to 0.94. The experimental results and the analysis indicated that moisture and ash contents were the major variables for the four types of dust. Extrapolation of the models to a moisture-free basis yielded values of C_{min} that were consistent with those reported in the literature. Extrapolation of the models to the moisture and ash contents, which are necessary for a completely inert dust sample, yielded values of moisture and ash content consistent with those reported in the literature. We also examined optically the ignition delay between dispersion and ignition of grain dust.

The maximum explosion pressure, the maximum rate of pressure rise, and the average rate of pressure rise were determined for all size fractions of dust. Each of the characteristics was correlated with the D_m and with each composition component. According to models developed in this work, a linear correlation should exist between each of the characteristics of grain dust and S_{ext}. For grain sorghum dust and corn dust, each characteristic exhibited a linear correlation below a particular value of S_{ext}. The contents of ash and moisture appeared to be determining factors for weight percents above approximately 12 percent to 15 to 25 percent, respectively. The effect of concentration on each correlation also was examined. For particles with diameters less than approximately 15 μm, the most hazardous condition occurred at the lowest concentration examined, 0.2 kg/m^3.

Rheological Properties of Grain Dust

We measured the rheological properties of wheat, corn, and grain sorghum dusts at three moisture contents. A Dillon Universal tester was used to determine the stress-strain relationship of grain dust from which the degree of elasticity, mechanical hysteresis, and pressure-density relationship of grain dust was obtained.

A test apparatus designed and constructed at the USGMRL was used to determine the stress relaxation and compression creep properties of grain dust. Results indicated that stress relaxation and compression creep properties of grain dust can be described, respectively, by Maxwell and Burger models.

In Situ Measurement of Grain Dust/ Particle Size Distribution and Concentration

A light extinction method for determining the particle size distribution and concentration of grain dust that is suspended in air in a grain bin was developed. We determined the particle size distribution by analyzing the change in light attenuated as particles settled out of the dust cloud. If the steady state particle size

distribution is equal to values determined by settling, the steady state dust mass concentration can be calculated. Data were obtained at several locations in a grain bin using the light extinction method, a high-volume air sampler, and the weight of dust settled on a horizontal surface. Light extinction measurements were made as the bin was spout, choke, and nozzle filled with corn and wheat and as the bin was filled with corn with 2-point and 4-point spreaders. Several dust-generating conditions were studied as the bin was filled with corn or wheat.

Bulk Properties of Corn and Fine Material Distribution as Affected by Multiple-Point, Self-Propelled Grain Spreader

When a bin is filled with a stream of grain from a gravity spout, the fine material concentrates in an area under the filling point. Because fine material has higher resistance to airflow than a bulk of whole kernels, segregation of fine material causes an uneven distribution of airflow within the grain mass and results in nonuniform drying and hot spots.

Motor-powered mechanical grain spreaders have been used to reduce segregation of fine material and provide a reasonably level surface when filling bins with grain. Grain possesses considerable potential and kinetic energy when it is delivered to the top of a grain bin by a grain elevator or an auger conveyor for filling. Using that energy to drive a grain spreader saves electrical power and eliminates electrical wiring and electrical fire hazards. Thus, we need to develop a self-propelled grain spreader that can uniformly distribute fine material in a grain mass and provide a level surface of grain in a bin.

A self-propelled, 4-point grain spreader developed at the USGMRL was used to fill bins with corn. Its use significantly improved the uniformity of fine material distribution in the grain mass but increased the dustiness of air in the bin. The bulk density and airflow resistance of corn in a bin filled with the grain spreader were higher than those values for corn in the bin filled without a spreader. The surface contour of the grain pile was reasonably level and symmetrical, with respect to the bin center when the 4-point spreader was used. Grain damage caused by the spreader was not significantly different from that observed when no spreader was used.

We studied the effect of fine material distribution in a grain bin on the drying rate. If a grain bin is filled by a spout in the center of the bin, the radial variation in the moisture content at a fixed position from the drying floor can equal the total axial variation in moisture content at a fixed radial position. The surface airflow also appears to be directly affected by the fine material distribution.

Computer Facilities

Computer facilities provide services to all researchers at the USGMRL. Our computing requirements are served by two minicomputers and a terminal. The first minicomputer is used to gather data from nonstandard peripheral devices and to input data from standard devices such as punch paper tapes and keyboards. We use the second minicomputer for statistical analysis and larger number manipulations. Both computers have extensive, in-house developed, graphical capabilities that are used by laboratory researchers. Programming assistance is available to individual researchers, so computer techniques can be used to solve their particular problems. All laboratory units have active computer programs.

GRAIN QUALITY AND END-USE PROPERTIES UNIT

Research activities in the Grain Quality and End-Use Properties Unit are concerned with (1) identifying physical and structural characteristics and chemical components that govern or are associated with functional properties; (2) developing, improving, and evaluating methods and instruments that can be used to objectively, rapidly, and accurately characterize and evaluate grain in domestic and export marketing channels; and (3) cooperating with plant breeders throughout the Great Plains and with agronomists, plant physiologists, entomologists, and biochemists at Kansas State University by providing milling, baking, and biochemical expertise and support for selective projects of mutual interest. Specifically, researchers

(a) Determine and evaluate the functional (milling and breadmaking) properties of early generation and potentially new hard winter wheats bred for the Great Plains and evaluate the earliest feasible generation of hard winter wheats bred for genetically high-protein content. Kjeldahl (protein) analytical equipment and the 10-g mixograph, together with micro- and macro-milling and breadmaking equipment, are employed to determine functional properties of about 2,500 plant breeders' samples (10 g to 1,500 g).

(b) Develop new methods and techniques of determining chemical, milling, breadmaking, physical-chemical, and biochemical properties of hard wheats.

(c) Develop energy-conserving baking methods and high-protein and nutritionally improved breads.

(d) Develop physical and biochemical fractionating and reconstituting techniques to relate functional (breadmaking) to biochemical properties of wheat-flour components and determine the chemical fractions and components of wheat responsible for quality differences. After literally taking the flours apart, corresponding gluten-protein, gliadin- and glutenin-protein, modified and unmodified, and other wheat-flour fractions of good and poor quality wheat flours are interchanged, one at a time and in combinations, in the reconstituted flours. Fractions and reconstituted flours are characterized by physical, biochemical, and breadmaking techniques. Research during the past year has been in the following areas:

Determining and Evaluating Functional Properties of Potentially New Hard Winter Wheats

About 585 samples, each about 1,500 g, of agronomically promising new varieties and recent releases of hard winter wheat were characterized and evaluated in terms of their functional properties including wheat hardness; bolting properties and flour yield; flour ash; dough mixing, oxidation, and water requirements; bread crumb grain and color scores; and loaf-volume (LV) potential. About 21 percent of the samples had good milling, chemical, breadmaking, and physical dough properties. Leading commercial wheat varieties of tomorrow are among them, and a number of progenies, in addition, had genetically high protein contents.

About 570 small samples (40 g to 100 g) of early generation progenies of hard winter wheats were micromilled and evaluated for milling. We subjected each sample of flour to certain analytical, water-absorption, and mixogram tests. About 213 (37.4 percent) had promising overall functional properties. Also, 145 of the 213 promising ones had 1 to 5.7 percentage points and 58 had 2.5 to 5.7 percentage points more flour protein than their controls.

From 1975-80, average wheat yield in Kansas (31.6 bu) was 7.4 bu greater, and average wheat protein content (12.0 percent) was 0.3 percent higher than the corresponding averages for the 1960's. Thus, the gradual decline in wheat protein content apparently has been halted and reversed during the past 6 years by high protein 'Eagle' and other relatively new Kansas varieties of hard winter wheat. Additionally, during the last 4 years (1977 to 1980), average wheat yield in Kansas (32.6 bu) was 8.4 bu greater and average wheat protein content (12.2 percent) was 0.5 percent higher than the corresponding averages for the 60's.

Low-Lactose Bread

Satisfactory, low-lactose, white-panned bread made from a dough that contains 6 percent sugar (flour basis) can be produced from milk that has been treated with lactase. To prepare such bread by a straight-dough procedure, however, two requirements must be met: malt with or without sucrose must be added to the dough to supplement the amount of lactose-derived glucose, and the lactase-treated milk, like regular milk, must be heat treated.

Counteracting the Deleterious Effects of Fiber in Breadmaking

Blends of wheat flour and wheat bran, corn bran, soybean bran, or coconut residue were baked into bread. The deleterious effects of up to 15 parts wheat bran per 85 parts wheat flour could be counteracted largely with the addition of vital gluten and one of several surfactants including diacetyl tartaric acid esters (DAT), ethoxylated monoglycerides (EMG), lecithin (LEC), sucrose monopalmitate (SMP), and sodium stearoyl-2-lactylate (SSL), alone or in combination with shortening. In the absence of shortening, 1 g each of DAT, EMG, or SMP per 100 g of mixture materially increased LV more than that with shortening. In the presence of 3 g shortening per 100 g of mixture, adding 0.5 g DAT, EMG, LEC, SMP, or SSL produced only small improvements above those when adding shortening alone.

Alpha-Amylase in Field-Sprouted Wheats: Its Distribution and Effect on Japanese-Type Sponge Cake and Related Physical and Chemical Tests

To clarify the effect of field-sprouting on quality, we determined α-amylase activity (0 to 4.13 dextrinizing units (D.U./g) in typical field-sprouted (0 to 36.2 percent) soft, white, winter wheat composites and their mill fractions and studied its effect on Japanese-type sponge cake and related tests. Average yields of the corresponding mill fractions of seven wheat composites were patent flour, 45 percent; midpatent flour, 10 percent; clear flour, 15 percent; bran, 25.8 percent; shorts, 3.2 percent; and red dog, 1.0 percent. Ash and protein contents of the fractions were typical. Alpha-amylase activity (D.U./g material) was relatively low for 45 percent patent, midpatent, and clear flours and relatively high for bran, shorts, and red dog. When α-amylase activity expressed as D.U./g material was cal-

culated as D.U./g wheat, based on yield, activity increased linearly in each mill fraction with increasing wheat α-amylase. When expressed as percent of wheat D.U., bran accounted for 42 percent of the α-amylase activity; patent flour, 32 percent; shorts, 9 percent; clear flour, 8 percent; midpatent flour, 7 percent; and red dog, 2 percent. Sponge cake volume increased from 1,280 cc (control) to 1,315 cc for the flour milled from wheat containing 0.35 D.U./g. Thereafter, volume decreased rapidly to 908 cc as D.U./g of wheat increased to 4.13. At least 0.2 D.U./g of wheat (about 2.5 percent sprouted wheat) should be a doubly safe level that would have no adverse effect on sponge cake quality. Sponge cake volume, sprouted wheat (percent), amylograph viscosity, falling number, and gas production were all functions of the α-amylase activity of wheat or flour. Different levels of field sprouting should not be assimilated by supplementing unsprouted wheat with a highly sprouted one, and especially not with a highly malted barley.

Gasograph: Design, Construction, and Reproducibility of a Sensitive 12-Channel Gas-Recording Instrument

The gasograph is an instrument designed to measure and to record, continuously, the gas produced in 12 fermenting doughs (about 10 g of flour). Values are recorded as gasograph units (GU), which readily can be expressed as millimeters of mercury or cubic centimeters of gas. Gasograph, channel-to-channel reproducibility is at least equal to that of different manometric-type and gauge-type nonrecording instruments.

The first two gasographs produced essentially identical results on successive days at two research laboratories, comparing fermentation rates of two yeast levels (3.5 and 7.25 percent) and three, straight grade, baker's flours formulated in sponges containing 6 percent sucrose, 1.5 percent sodium chloride, and 150 percent water, in addition to flour and yeast. The average of the coefficients of variability of treatments within laboratories was 0.55 percent and within channels between laboratories was 0.75 percent. Thus, the excellent reproducibility between laboratories was somewhat lower than that within laboratories. Typical gasograms demonstrate the high reproducibility of the actions of formula ingredients, yeast, sugar, and diastatic malt. The coefficient of variability was 0.69 percent.

The gasograph can be used to indicate the presence or absence of inhibitors or stimulators of yeast respiration and to investigate the interaction of formula ingredients and fermentation rates during various stages of the fermentation and proofing of dough. Traces of α-amylase in wheat and flour can be detected easily with the instrument.

The Amino Acid Composition of Grain Dusts

The amino acid composition of wheat, corn, grain sorghum, soybeans, a wheat-corn mixture, and rice and dust from those grains was determined by automated ion-exchange analysis. Protein content was 2 to 3 percentage points (d.b.) less in dust than in the corresponding grain, except for soybeans. The protein content of soybean dust was about 13 percent compared to about 41 percent in soybeans. The concentration of lysine, the limiting amino acid in most grains, was higher in each type of dust, with the exception of soybeans, than in the parent grains. Protein of all dust samples contained less leucine than protein of the parent grains.

Defatted and Reconstituted Wheat Flours. Effects of 0 to 12 percent Shortening (Flour Basis) in Breadmaking

Petroleum ether (PE) extracted from 10 g (dry basis) of a composite flour of HRW wheats, 91 mg free lipids (69 mg nonpolar (NL) and 22 mg polar (PL)) and 2-propanol (2-PrOH) extracted 136 mg total lipids (TL) (free plus most of bound) (69 mg NL and 67 mg PL). Extracted and reconstituted flours were baked with 0, 0.375, 0.75, 1.5, 3, 6, 9, and 12 percent commercial shortening. In general, mixing time increased and water absorption decreased as the shortening level increased. LV obtained using the control flour increased rapidly as the shortening increased up to 1.5 percent and changed little after 3 percent. Shortening increased LV of PE defatted flour and its NL-reconstituted flour but decreased LV of 2-PrOH defatted flour and its NL-reconstituted flour. Shortening increased, slightly, LV of PE, or 2-PrOH defatted flours reconstituted with PL. For reconstituted flour containing total PL but no NL, only about 0.5 percent shortening was enough for optimum LV and crumb grain, provided only free PL had been removed originally. However, if total PL had been extracted and then added back to 2-PrOH defatted flour, 3 percent shortening was required for good LV. Insofar as LV and crumb grain were concerned, wheat flour free PL could be replaced by 9 to 12 percent shortening, irrespective of the presence of NL, whereas total PL could not be replaced by any level of shortening. We compared the significance of native flour PL as a function of shortening level.

Hard Red Winter Wheats Vary Both in Breadmaking Potential and in Free Polar-Lipid Content

Free lipids were extracted with PE, in a Soxhlet, from 21 samples of HRW wheats and 23 samples of experimentally milled flours (70.6 to 76.8 percent extraction), which varied in breadmaking potential. Wheat protein content ranged from 11.5 to 15.7 percent, flour mixing time from 7/8 to 9 min, and LV (100 g flour) from 523 to 1,053 cc. The free TL's from 10 g flour (d.b.) were fractionated into PL and NL lipids, and TL was analyzed for carbohydrates, mainly galactose (GAL), colorimetrically. PL content ranged from 14.8 to 28.1 mg/10 g wheat and from 10.6 to 27.3 mg/10 g flour; NL/PL ratios were from 6.31 to 11.32 for wheat and 2.47 to 6.91 for flour; lipid GAL ranged from 1.61 to 5.45 mg and from 2.64 to 5.61 mg in 10 g of wheat and flour, respectively. We found significant linear correlations between LV and the following parameters: PL content ($r = 0.877$ for wheat and 0.888 for flour); NL/PL ($r = -0.902$ for wheat and -0.907 for flour); and lipid GAL ($r = 0.745$ for wheat and 0.905 for flour). PL, NL/PL, and lipid GAL were related curvilinearly to mixing time and were related linearly to the log of mixing time. The r values for the correlations of LV or log mixing time with PL, NL/PL, and lipid GAL were about the same whether or not LV and mixing time were corrected on the basis of constant protein content.

This indicates that protein quality has a great effect on breadmaking characteristics, and that, to a large extent, the quantity of PL or galactolipids occurring naturally in wheat governs the quality differences observed between wheats. The highly significant correlations point to the potential usefulness of PL, NL/PL, and lipid GAL for predicting LV potential of HRW wheats or flours.

Correct-Side Break and Shred Improves Reproducibility of the 100-gram Bake Test

Essentially 100 percent correct-side break and shred and the lowest LV deviation of bread (100 g flour) were obtained when the inside surfaces of unglazed pans had an adequate coat of shortening, except for the top one-third of the side away from the worker when the convex side of the dough crease is toward the side near the worker. Although pans with no shortening on the top one-third of one side were used in this study, a much smaller dry area will produce similar results, a condition possible in the daily routine of greasing bread pans. Too little or too much shortening also produced undesirable breaks and shreds.

Sucrose Mono and Diesters in Breadmaking

Sucrose esters of nine fatty acids were synthesized in *N, N*-dimethylformamide solution by transesterification between sucrose and a methyl ester of a fatty acid. Sucrose, mono, and diester fractions were purified from the crude products by chromatography on silica gel. The pure fractions were tested in breadmaking for their improving effects in microloaves baked from a soy-fortified, no-shortening formula. In the series of mono esters of saturated fatty acids of chain-length C-8 through C-20, the C-16 and C-18 esters performed best at 0.25 percent, whereas the C-12 ester was best at 0.5-0.75 percent. In the diester series the C-12 diester of 1.0-1.5 percent gave excellent LV and crumb grain. The diester fraction of sucrose palmitate alone performed poorly in improving LV. However, sucrose dipalmitate and higher esters of sucrose palmitate increased the loaf-improving effects of sucrose monopalmitate. Thus, unfractioned sucrose palmitate was an excellent dough strengthener at 1.25-2.0 percent. Sucrose monocaprylate and monocaprate reduced dough mixing time by about 15 percent.

Aid to Chromatographers: A Simple Trap That Eliminates Bubbles in the Solvent Intake of High-Pressure Liquid Chromatography Pumps

Small bubbles sometimes found in the inlet line to high-pressure pumps can be eliminated by a simple bubble trap. The bubbles usually are caused by incomplete degassing or solvent changeover. The bubbles can cause erratic pumping and false peaks in the chromatogram.

A simple, cylindrical, glass bubble-trap in a vertical position below the solvent reservoir and above the inlet to the pump eliminates the bubbles, which stay at the top of the tube and can be eliminated easily by venting the top stopper. Additionally, the trap allows visual inspection of solvent changeover because of the vortexing of two solvents that differ in refractive index. Suitable traps are available from Beckman Instruments Inc. (part no. 326187) and Flarefit (catalog no. 24135).

Analysis of Coumestrol, a Plant Estrogen, in Animal Feeds by High-Performance Liquid Chromatography

Coumestrol, a phytoestrogen, was determined in animal feeds by high-performance liquid chromatography. The coumestrol concentration was determined in feeds being fed to animals showing physiological effects of high-estrogen levels and to animals where no physiological effect was noticed. The data implies that animals fed haylage containing 37 ppm coumestrol or more as their major feed will show physiological estrogenic effects.

Purification and Characterization of a Corn (*Zea mays*) Protein Similar to Purothionins

Extracting PE-defatted ground corn (*Zea mays*) with dilute sulfuric acid yielded six protein fractions, each of which contained large numbers of basic amino acid and cysteine residues. All of the proteins appeared to be similar in size and amino acid composition to the purothionins found in wheat flour. One protein was almost identical in amino acid composition to the thionin recently isolated from rye flour. This protein, corn protein I, was hydrolyzed with chymotrypsin and yielded four peptides, none of which resembled the two peptides released from purothionins under identical conditions. None of the six proteins was toxic when injected into tobacco hornworm (*Manduca sexta*) larvae. Even though the corn protein I is very similar to purothionins and rye thionin in amino acid composition and in several chemical and physical properties, it is probably not homologous in primary structure.

Sequences of Purothionins and Their Inheritance in Diploid, Tetraploid, and Hexaploid Wheats

Purothionins are small, basic proteins found in the genus *Triticum*. Hexaploid wheat (*T. aestivum*), with genomes A, B, and D, produces three forms of purothionin (α_1, α_2, and β) that are all similar in amino acid sequence. Tetraploid wheat (*T. durum*), with genomes A and B, produces two forms (α_1, β), whereas a diploid wheat (*T. monococcum*), with only the A genome, produces only β-purothionin. The amino acid sequences of the purothionins examined have been completely conserved during the period in which hexaploid wheat originated from its progenitors.

Amino Acid Sequences of Thionins from Various Cereals: A Review

Thionins are small, toxic proteins found in the endosperms of several different cereals. Purothionins have been isolated from diploid (*T. monococcum*), tetraploid (*T. durum*), and hexaploid (*T. aestivum*) wheats. From the amino acid sequences of these purothionins and our knowledge of the genetics of the wheats, we found that the gene coding for α_1-purothionin is a part of the wheat B genome, that coding for α_2-purothionin is in the D genome, and that the A genome contains the gene for β-purothionin. Thionin-like proteins have been isolated from barley, corn, and rye. The barley and rye proteins have primary structures homologous to purothionins; corn protein is not homologous with purothionin.

ECONOMICS AND STATISTICS SERVICE[1]

National Economics Division

Research activity of this unit encompasses the economic evaluation of a wide variety of subjects related to producing and marketing grain and grain products. General research areas include grain quality, production costs, storage, and marketing and transportation analysis. Special areas of research include assessing such current issues as dust emission, solar grain drying, and analyzing data used in making public policy decisions.

Main objectives of these economic evaluations are (1) to provide economic assessments of new technologies and approaches to grain production and marketing, such as comparing costs of solar and conventional grain-drying systems and estimating costs of pelletizing grain dusts; (2) to analyze the efficiency of assembling, processing, and distributing grain and grain products; (3) to conduct supply-demand analyses; (4) to estimate costs of producing and marketing grains and grain products, including white pan bread; and (5) to provide quick analyses of current topics.

Basic to the research efforts of this group, headquartered in Washington, D.C., is the interdisciplinary approach and environment afforded by the USGMRL. This unit works in close cooperation with USDA's SEA-AR personnel, as well as with personnel at Kansas State University.

[1]Formerly the Economics, Statistics, and Cooperatives Service.

VISITORS TO THE U.S. GRAIN MARKETING RESEARCH LABORATORY

Many hundreds of visitors to the USGMRL came from 30 states of the United States and 54 countries throughout the world. We can not, in the short space available, list all the distinguished visitors. We would like, therefore, to acknowledge here major groups that came at the invitation of several sponsoring organizations. The Kansas Wheat Commission, in cooperation with U.S. Wheat Associates Inc., and USDA's FAS sponsored wheat teams from Columbia, Lebanon, Pakistan, and Roumania, a miller's team from Southeast Asia, and a Latin American Millers' Short Course (Bolivia, Chile, Columbia, Ecuador, Guatemala, Mexico, and Peru). A Japanese milling team was sponsored by the Agricultural, Forestry, and Fisheries, Productivity Conference, Japan, the Japanese Milling Industry and FAS.

We organized a tour for, and lectured to, participants from Brazil, Burundi, Costa Rica, Ecuador, Honduras, India, Japan, Kenya, Malaysia, Mali, Mexico, Nicaragua, Nigeria, Philippines, Togo, and Upper Volta in a Grain Storage and Marketing Short Course. Four groups from the People's Republic of China included a group from the Henan Province (sponsored by the Kansas Department of Economic Development), a Feed Grain Team (U.S. Feed Council, FGIS, FAS, and SEA), a General Administration Team for Inspection of Import and Export Commodities (FGIS, FAS, and SEA), and a Grain Storage and Handling Delegation (USDA, Office of International Cooperation and Development).

Several large groups of participants in short courses organized by the American Institute of Baking visited our facilities. Kansas State University sponsored tours of classes in agronomy, biology, biochemistry, crop science, and agricultural engineering and a short-course farm group. We were visited by participants in an agricultural research methodology short course (Bangladesh, Dominican Republic, Jamaica, Kenya, Malaysia, Mauritania, Philippines, Saudi Arabia, Thailand, and Yemen); in a USDA FAS-Career Development Program; in an International Grain Program for U.S. Wheat Associates Inc. representatives stationed in important wheat purchasing offices around the world; and in a short course for members in the International Farmers Association for Education (Brazil, France, Japan, People's Republic of China, and the Philippines).

And last, but certainly not least, we were visited by many groups representing the scientific and technical community, the general public, clubs, schools, colleges, and companies. Last year, I indicated that the frequent and, to the best of my knowledge, only complaint we received was in the form of a regret that not enough time was scheduled for a more thorough and detailed visit. We were gratified, therefore, to follow the many contacts that we've established, including letters, phone calls, and repeated visits.

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Hopkins, T. A., Kramer, K. J., and Ahmed, R. December 15. 1980. Tyrosine metabolism for cuticle tanning in insects. American Society of Zoology, Seattle, Wash.

Hubbard, J. D., Martin, C. R., Lai, F. S., Miller, B. S., and Pomeranz, Y. October 28-November 1, 1979. The amino acid composition of grain dusts. 64th Annual meeting, American Association of Cereal Chemists, Washington, D.C.

Jones, B. L., Cooper, D. B., and Lookhart, G. L. October 28-November 1, 1979. Purothionins and homologous proteins from various grains. 64th Annual meeting, American Association of Cereal Chemists, Washington, D.C.

______ August 24-29, 1980. Amino acid sequences of thionins from various cereals. 2nd Chemical Congress of the North American Continent, Las Vegas, Nev.

______ Lookhart, G. L., Hall, S. B., and Finney, K. F. September 21-25, 1980. Polyacrylamide gel electrophoretic patterns of gliadin proteins from the 80 most commonly grown U.S. wheat varieties. 65th Annual meeting, American Association of Cereal Chemists, Chicago, Ill.

Kramer, K. J. November 29, 1979. Insect peptide hormones. Department of Anatomy and Physiology, Kansas State University, Manhattan.

______ March 13, 1980. Biochemistry of insect development. Departments of Biology and Chemistry, Kansas Wesleyan College, Salina, Kans.

______ and Seib, P.A. August 26, 1980. Ascorbic acid and insect growth and development. Annual meeting, American Chemical Society, Las Vegas, Nev.

Lee, R. S., Aldis, D. F., Lai, F. S., and Rousser, R. September 17, 1980. A high-energy chemical igniter for dust cloud ignition. Fine Particle Society meeting, University of Maryland, College Park.

Lookhart, G. L., Finney, K. F., and Finney, P. L. October 28-November 1, 1979. Coumestrol in germinated soybeans and their fractions. 64th Annual meeting, American Association of Cereal Chemists, Washington, D.C.

______ August 24-29, 1980. High-performance liquid chromatographic analysis of a phytoestrogen, coumestrol, in animal feeds. 2nd Chemical Congress of the North American Continent, Las Vegas, Nev.

______ Jones, B. L., and Hall, S. B. September 21-25, 1980. Variables affecting polyacrylamide gel electrophoretic patterns of wheat gliadin proteins. 65th Annual meeting, American Association of Cereal Chemists, Chicago, Ill.

Martin, C. R., Lai, F. S., Chang, C. S., and Miller, B. S. June 15-18, 1980. Reducing dust emissions by use of a grain nozzle. American Society of Agricultural Engineers summer meeting, San Antonio, Tex.

Mathewson, P. R., Miller, B. S., Pomeranz, Y., Booth, G. D., and Fahrenholz, C. H. October 28-November 1, 1979. A collaborative study of sprouted wheat by colorimetric alpha-amylase, falling number and amylograph assays. 64th Annual meeting, American Association of Cereal Chemists, Washington, D.C.

______ Pomeranz, Y., Miller, B. S., and Fahrenholz, C. H. May 8-9, 1980. Determination of sprout damage in cereal grain by a rapid, simplified procedure; development of a new instrument for grain evaluation. 10th Annual spring technical conference of the American Association Milling and Baking Division, Kansas City, Mo.

______ Fahrenholz, C. H., and Pomeranz, Y. September 21-25, 1980. Colorimetric determination of alpha-amylase in sprouted grains and malts. 65th Annual meeting, American Association of Cereal Chemists, Chicago, Ill.

McGaughey, W. H. November 25-29, 1979. Chairman, informal conference on control of stored product insects. Annual meeting, Entomological Society of America, Denver, Colo.

______ and Dicke, E. B. November 25-29, 1979. Methods of applying *Bacillus thuringiensis* to stored grain for moth control. Annual meeting, Entomological Society of America, Denver, Colo.

Miller, B. S., Lee, M. S., Hughes, J. W., and Pomeranz, Y. October 28-Nov. 1. 1979. Measuring high moisture content of cereal grains by pulsed NMR. 64th Annual meeting, American Association of Cereal Chemists, Washington, D.C.

______ January 3, 1980. Report on work plan for NC-151. Objective B—To relate quality factors to urgent problems of safety and health such as dust explosions, mytoxin, and heavy metal contamination, Chicago, Ill.

______ April 10, 1980. Review of progress on grain dust research. 27th Soft Wheat Quality Laboratory Research Review Conference, Wooster, Ohio.

______ April 11, 1980. Research on hard red winter wheat that may be useful for research on soft winter wheat. 27th Soft Wheat Quality Laboratory Research Review Conference, Wooster, Ohio.

______ April 24, 1980. Report on objective methods for determining the classing of wheat. Public meeting (FGIS) on the problem of wheat classing, Kansas City, Mo.

______ April 29, 1980. Review of progress on grain dust research. 84th Annual technical conference and trade show of the Association of Operative Millers, Dallas, Tex.

______ May 6, 1980. Lecture: Cereal and foods analysis class on methods for measuring the quality of grain in marketing channels. Department of Grain Science and Industry, Kansas State University, Manhattan.

______ Afework, S., Pomeranz, Y., and Bolte, L. September 21-25, 1980. Wheat hardness. II. Measurement of wheat hardness with a Brabender automatic micro-hardness tester. 65th Annual meeting, American Association of Cereal Chemists, Chicago, Ill.

______ Hughes, J. W., Afework, S., and Pomeranz, Y. September 21-25, 1980. Wheat hardness I. Work required to grind wheat measured by a modified Brabender hardness tester. 65th Annual meeting, American Association of Cereal Chemists, Chicago, Ill.

Mueller, D. D., and Kramer, K. J. October 26, 1979. Phosphorus-31 NMR of insect hemolymph sera. West Central States Biochemical Congress, Kansas City, Mo.

Pomeranz, Y. October 9, 1979. Research philosophy at the U.S. Grain Marketing Research Laboratory. Agricultural Experiment Station luncheon, Kansas State University, Manhattan.

______ October 28-November 2, 1979. Wrap-up of symposium, "Lipid-Related Materials in Breadmaking." 64th Annual meeting, American Association of Cereal Chemists, Washington, D.C.

______ Davis, G. D., Stoops, J. L., and Lai, F. S. October 28-November 2, 1979. Test weight and groat-to-hull ratio in oats. 64th Annual meeting, American Association of Cereal Chemists, Washington, D.C.

______ November 2, 1979. Objectives and international activities of the U.S. Grain Marketing Research Laboratory. International Agribusiness Colloquium, Kansas State University, Manhattan.

______ January 14, 1980. Grain dust—an update and projection. Safety Committee, National Association of Wheat Growers, 30th Anniversary Convention, Phoenix, Ariz.

______ January 3-5, 1980. Chairman, Annual meeting, Project NC-151, Marketing and delivery of quality cereals and oilseeds in domestic and foreign markets, Kansas City, Mo.

______ February 12, 1980. Molecular approach to breadmaking. Joint seminar, Department of Agronomy and Range Science and Food Science and Technology, University of California, Davis.

______ March 12, 1980. Flour supplementation. Romanian Wheat Team, Kansas State University-U.S. Wheat Associates Inc., Manhattan.

______ April 11, 1980. Research priorities of the 80's. NC-120 Regional Research Committee, Manhattan, Kans.

______ April 14, 1980. The biochemistry of breadmaking. Short course, American Association of Cereal Chemists, Minneapolis, Minn.

______ April 14, 1980. Structure, composition, and end-uses of cereals. Short course, American Association of Cereal Chemists, Minneapolis, Minn.

______ April 28, 1980. Lecithin, the thing it does, can (or cannot) do, and can be made to do in baking. International Society of Fat/American Oil Chemists' Society World Congress, New York, N. Y.

______ April 28-30, 1980. Interaction between lipids and gluten proteins. Workshop on the Physico-Chemical Properties of Gluten Proteins, Nantes, France.

______ April 29, 1980. An ideal surfactant in breadmaking. International Society of Fat/American Oil Chemists' Society World Congress, New York, N. Y.

______ April 29, 1980. Chairman, Symposium on lipids in baking. International Society of Fat/American Oil Chemists' Society World Congress, New York, N. Y.

______ May 2, 1980. Molecular approach to breadmaking. Institute of Food Chemistry, University of Munster, West Germany.

______ May 7, 1980. Cereal chemistry and technology—the past, present, and future. Plenary lecture, 10th Congress, International Association of Cereal Chemists, Vienna, Austria.

______ May 8, 1980. Chairman, Symposium on starch. 10th Congress, International Association of Cereal Chemists, Vienna, Austria.

______ May 12, 1980. Molecular approach to breadmaking. Danish Cereal Society, Copenhagen, Denmark.

______ May 12, 1980. Structure, composition and end-use properties of cereal grains. Danish Cereal Society, Copenhagen, Denmark.

______ June 5, 1980. Flour supplementation. Latin American short course, Kansas State University-U.S. Wheat Associates Inc., Manhattan.

______ June 10, 1980. Co-chairman, Symposium on cereal grain products:bioavailability of nutrients. 40th Annual meeting, Institute of Food Technologists, New Orleans, La.

______ September 21-25, 1980. Phosphatides: occurrence, types, and role in baking. 65th Annual meeting, American Association of Cereal Chemists, Chicago, Ill.

______ September 24, 1980. What? How much? Where? What Function? in breadmaking. Thomas Burr Osborne Medal Award-Address. 65th Annual Meeting, American Association of Cereal Chemists, Chicago, Ill.

______ September 21-25, 1980. Nondestructive testing—wrap-up of symposium. 65th Annual meeting, American Association of Cereal Chemists, Chicago, Ill.

_____ September 21-25, 1980. Wheat endosperm structure and end use properties. 65th Annual meeting, American Association of Cereal Chemists, Chicago, Ill.

Quinlan, J. K. November 25-29, 1979. Aerosol application of malathion using aeration in 8-metric columns of shelled corn. National meeting, Entomological Society of America, Denver, Colo.

_____ February 19-21, 1980. The present and future of stored grain protectants. Fumigation short course, University of Kentucky, Owensboro.

_____ March 25-27, 1980. Malathion residues in sized cracked-wheat dockage. North Central Branch Meeting of the Entomological Society of America, Lincoln, Nebr.

_____ April 26, 1980. Levels of malathion on wheat stored at various temperatures and moisture. Central States (Kansas) Entomological Society, Lawrence, Kans.

Sauer, D. B. February 14-15, 1980. (1) Microflora of stored grain and their control. (2) Mycotoxins in stored grain. Presented at Foreign Agriculture Office sponsored short course, University of Costa Rica, San Jose.

_____ March 6, 1980. Proper storage requirements for feed grains, soybeans, and soybean meal in warm, humid climates. Symposium on Grain and Meal Storage, Mexico City, Mexico.

_____ August 25, 1980. Mycotoxins: status of chemical control. Annual meeting, American Phytopathological Society, Minneapolis, Minn.

Schnake, L. D. October 3, 1979. Costs of pelleting grain dust. Proceedings, International Symposium on Grain Dust, Kansas State University, Manhattan.

_____ April 15, 1980. A review of bread margins. Prepared for the Economics and Statistics Service, U.S. Department of Agriculture.

_____ May 21, 1980. Economic and environmental impact of OSHA proposed regulations to protect the safety and health of grain handlers. Prepared for the Office of the Secretary, U.S. Department of Agriculture.

_____ July 8, 1980. OSHA proposed electrical code regulations for grain handling facilities. Materials prepared for briefing Secretary, U.S. Department of Agriculture.

Seitz, L. M. March 26, 1980. Chemical methods for measuring fungal growth on grains: applications in small-scale laboratory experiments and in 100-bu corn storage tests. Seminar, U.S. Grain Marketing Research Laboratory, Manhattan, Kans.

_____ Sauer, D. B., Mohr, H. E., and Aldis, D. September 21-25, 1980. Storage of high-moisture corn: mold growth and dry matter loss. 65th Annual meeting, American Association of Cereal Chemists, Chicago, Ill.

_____ September 21-25, 1980. Nuclear magnetic resonance for nondestructive testing of cereal grains. 65th Annual meeting, American Association of Cereal Chemists, Chicago, Ill.

Shogren, M. D., Pomeranz, Y., and Finney, K. F. October 28-November 1, 1979. Counteracting the effects of fiber in breadmaking. 64th Annual Meeting, American Association of Cereal Chemists, Washington, D.C.

_____ and Finney, K. F. September 21-25, 1980. Correct-side break and shred improves reproducibility of the 100-gram bake test. 65th Annual meeting, American Association of Cereal Chemists, Chicago, Ill.

Storey, C. L., Martin, C. R., and Sukkestad, D. R. October 3, 1979. Concentrations of 80:20 grain fumigant (CCl_4-CS_2) in handling equipment during transfers of fumigated wheat. International Symposium on Grain Dust, Kansas State University, Manhattan.

_____ October 5, 1979. Hay export fumigation-certification program. Annual conventions National Hay Association, Fort Walton Beach, Fla.

_____ May 12, 1980. Mortality of various stored product insects in low oxygen atmospheres produced by an exothermic inert atmosphere generator. International symposium, Controlled Atmosphere Storage of Grains, Castelgandolfo (Roma), Italy.

_____ May 14, 1980. Functional and end-use properties of various commodities stored in a low oxygen atmosphere. International symposium, Controlled Atmosphere Storage of Grains, Castelgandolfo (Roma), Italy.

_____ September 18, 1980. Nature of grain fumigants and application of grain fumigants. Commercial Pesticide Applicators Certification Program, Iowa State University, Ames.

_____ September 24, 1980. Use of ethylene dibromide in stored grain and flour mills. USDA-SEA Pesticide Impact Assessment meeting, Washington, D.C.

_____ September 30, 1980. Alternate methods to bin fumigation. 1980 Advanced Sanitation Course, American Institute of Baking, Washington, D.C.

Tyrell, D. J. and Bulla, L. A., Jr. February 8, 1980. Comparative biochemistry of entomocidal parasporal crystals of selected strains of *Bacillus thuringiensis*. Division of Biology, Kansas State University, Manhattan.

_____ and Bulla, L. A., Jr. March 28, 1980. Comparative biochemistry of entomocidal parasporal crystals of selected strains of *Bacillus thuringiensis*. Annual meeting, Missouri Valley Branch, American Society for Microbiology, Manhattan, Kans.

Tweeten, T. N., Wetzel, D. L., and Chung, O. K. October 28-November 1, 1979. A comparison of infrared and variable wavelength detectors for the determination of glycolipids in wheat flours using high performance liquid chromatography. 64th Annual meeting, American Association of Cereal Chemists, Washington, D.C.

_____ Wetzel, D. L., and Chung, O. K. April 27-May 1, 1980. Effects of column packings and solvent systems on the separation of glycolipids by high performance liquid chromatography. International Society of Fat/American Oil Chemists' Society World Congress, New York, N. Y.

SEMINARS PRESENTED AT THE U.S. GRAIN MARKETING RESEARCH LABORATORY

Aldis, D. F. March 5, 1980. Explosions and fires in dust clouds. U.S. Grain Marketing Research Laboratory, Manhattan, Kans.

Anderegg, B. March 27, 1980. Effects of environmental factors on the uptake of insecticides by plants. U.S. Grain Marketing Research Laboratory, Manhattan, Kans.

Andrews, R. E. March 19, 1980. The fate of dietary terpenes in the Douglas Fir Tussock Moth and their role in the insect's biochemistry. U.S. Grain Marketing Research Laboratory, Manhattan, Kans.

Brandner, L. E. February 13, 1980. Scientific writing. Agricultural Experiment Station, Kansas State University, Manhattan.

Bruinsma, B. L. April 9, 1980. Near-infrared reflectance spectroscopy—things it can and cannot do for you. U.S. Grain Marketing Research Laboratory, Manhattan, Kans.

Consigli, R. A. January 23, 1980. Evidence for involvement of viruses in cancer. Division of Biology, Kansas State University, Manhattan.

Deyoe, C. W. February 20, 1980. Research programs in the Department of Grain Science and Industry. Department of Grain Science and Industry, Kansas State University, Manhattan.

Erickson, L. E. January 29, 1980. Production of alcohol: separation and energetic aspects; biochemical and engineering aspects. Department of Chemical Engineering, Kansas State University Manhattan.

Fox, P. R. June 2, 1980. Dairy proteins. Department of Dairy and Food Chemistry, University College, Cork, Ireland.

Heid, W. G. February 6, 1980. U.S. wheat industry—trends. U.S. Grain Marketing Research Laboratory, Manhattan, Kans.

Kyle, B. G. January 29, 1980. Production of alcohol: separation and energetic aspects; biochemical and engineering aspects. Department of Chemical Engineering, Kansas State University, Manhattan.

Lillehoj, E. B. February 27, 1980. Mycotoxins in preharvest grain. Oilseed and Food Laboratory, Southern Regional Research Center, New Orleans, La.

Miller, B. S. April 2, 1980. Methods for measuring quality of grain in marketing channels. U.S. Grain Marketing Research Laboratory, Manhattan, Kans.

Sauer, D. B. April 30, 1980. Incidence of fungi and insects in export corn and wheat. U.S. Grain Marketing Research Laboratory, Manhattan, Kans.

Schruben, L. W. January 16, 1980. Public issues and alcohol motor fuel. Department of Economics, Kansas State University, Manhattan.

Seitz, L. M. March 26, 1980. Chemical methods for measuring fungal growth on grains: applications in small-scale laboratory experiments and in 100-bu corn storage tests. U.S. Grain Marketing Research Laboratory, Manhattan, Kans.

Storey, C. L. April 30, 1980. Incidence of fungi and insects in export corn and wheat. U.S. Grain Marketing Research Laboratory, Manhattan, Kans.

Walker, D. E. April 16, 1980. Hand-held calculators. U.S. Grain Marketing Research Laboratory, Manhattan, Kans.

STAFF

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